

# Mihail Pivtoraiko

*President & CEO, Aptonomy, Inc.*

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## Research Interests

Robotics and Artificial Intelligence: efficient, intelligent and reliable robot behaviors, fully autonomous systems and assisted teleoperation, motion planning and control for complex systems with kinematics and dynamics constraints in the presence of uncertainty and efficient execution requirements, mobile robotics, goal acquisition and navigation, mobile manipulation, surveillance, target tracking and multi-agent systems.

## Education

*Ph.D., Robotics*, February 2012

Carnegie Mellon University, Pittsburgh, PA

- Thesis: *Differentially Constrained Motion Planning with State Lattice Motion Primitives*
- Thesis Committee: Alonzo Kelly, Tony Stentz, Matt Mason and Steve LaValle (University of Illinois)

*B.S., Computer Engineering and Physics*, May 2003

Portland State University, Portland, OR

- Minor: *French*
- Honors College

## Professional Experience

2/2014–present    President & CEO

Aptonomy, Inc., Redwood City, CA

- Co-founded a research and development firm specializing in artificial intelligence and robotics.
- Led product development, market research and fundraising activities.

2/2012–2/2014    Postdoctoral Researcher

GRASP Laboratory, University of Pennsylvania, Philadelphia, PA

Supervisor: Vijay Kumar, Ph.D., [kumar@seas.upenn.edu](mailto:kumar@seas.upenn.edu)

- Served as the research and development lead for the ARL CANINE featuring an outdoor fully autonomous mobile manipulator, in partnership with SRI International.
- Developed and implemented motion planning and control algorithms for dexterous manipulation and whole-body motion of a bipedal humanoid robot as part of the DARPA Robot Challenge program, in partnership with Lockheed Martin ATL.
- Led an ARL MAST research effort to generate real-time aggressive motion maneuvers for a team of quadcopter micro-UAV's in cluttered, partially known environments.
- Co-authored several successful grant applications.

8/2010–2/2012    DARPA ARM-S Motion Planning Leader

Robotics Institute, Carnegie Mellon University, Pittsburgh, PA

Supervisor: Drew Bagnell, Ph.D., +1-412-418-2965, [dbagnell@ri.cmu.edu](mailto:dbagnell@ri.cmu.edu)

- Created the motion planning infrastructure for the project: robot model, inverse kinematics, arm and grasp planner hierarchy.

- Implemented the CHOMP motion planning algorithm, achieved over three-fold speedup via algorithmic improvements.
- Demonstrated dual-arm object grasping with the existing planning infrastructure.

8/2006–2/2012 Research Assistant

Robotics Institute, Carnegie Mellon University, Pittsburgh, PA

Supervisor: Alonzo Kelly, Ph.D., +1-412-576-9016, alonzo@cmu.edu

- Developed and evaluated search spaces for differentially constrained motion planning.
- Validated planner designs in simulation and on physical robots (JPL prototype rovers FIDO and Athena).
- Developed model-based predictive control software for off-road mobile robot navigation. Maintained an implementation of the Ranger navigation algorithm for the DARPA PerceptOR project.
- Designed a state lattice motion planner for car-like PerceptOR robots operating in cluttered natural environments.
- Supported the PerceptOR navigation system during several field tests and government demos: Fort A.P.Hill and Yuma Proving Grounds.
- Guided the system model identification work of PerceptOR robots with the emphasis on braking modeling.
- Led the effort to adapt PerceptOR navigation software for differential drive mobility of robots in the DARPA Learning Applied to Ground Robots (LAGR) program.
- Developed trajectory generation and motion planning systems for next generation Mars rovers as part of JPL Mars Technology Program.

6/2005–5/2006 Research Associate

Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA

Supervisor: Adrian Stoica, Ph.D., +1-818-642-6923, adrian.stoica@jpl.nasa.gov

- Researched and developed mobility, motion planning systems, and reconfigurable architectures for autonomous planetary rovers.
- Engineered autonomy systems for prototype rovers (Rocky8, FIDO, and Athena): state estimation, vision and perception, and navigation systems.
- Developed the Single Cycle Instrument Placement technology, targeted for future Mars missions.
- Developed ground support software for Mars Science Lab mission to allow coordinated motion of actuators for testing flight hardware.

6/2002–9/2002 Robotics Intern

Intel Corporation, Hillsboro, OR

Supervisor: Jim Butler, +1-503-264-0997, jim.butler@intel.com

- Developed software for an XScale (PXA250) based embedded platform designed as a supernode for Berkeley motes project and for robotics control applications.
- Ported a bootloader (“bootldr”) and Linux kernel to the new board.
- Designed Linux device drivers specialized for robotics applications.
- Provided technical support for platform deployments to several leading robotics research institutions.
- Outstanding Intern rating.

9/2001–12/2001 Research Assistant Intern

NASA, Goddard Space Flight Center, Greenbelt, MD

Supervisor: Per Gloersen, Ph.D., per.gloersen@gsfc.nasa.gov

- Coded Matlab MEX and C (including multi-threaded processes for four CPU's under HPUX) to process geophysical data from several defense meteorological satellites for climate research.
- Developed data visualization techniques to examine very large datasets.

6/2000–6/2003 Research Assistant

PSU Robotics Lab, Portland, OR

Supervisors: Marek Perkowski, Ph.D., mperkows@ee.pdx.edu and Douglas V. Hall, Ph.D., dough@ee.pdx.edu

- *Reversible circuit design*  
Implemented a genetic algorithm for automatic design of reversible logic circuits. Co-developed new representations for efficient circuit encoding.  
Conducted extensive experimentation and assessed the performance of the approach.
- *Computer vision on an ultra-low power computer*  
Ported, optimized and evaluated components of computer vision libraries (OpenCV, VxL, CMVision) on a single-board computer, "Stayton", based on a mobile XScale CPU.  
Constructed an autonomous mobile robot featuring vision-based navigation.
- *Hexapod robot soccer*  
Led a group of seven to develop a small league soccer system.  
Designed a set of six-legged walking robots.  
Setup the overhead camera vision system: adapted Player/Stage Mezzanine software, optimized the Linux device driver for fast picture acquisition.
- *Multi-arm coordination*  
Modified the existing hardware (6 robotic arms) to include sensors for joint angles for simultaneous control.  
Designed a complete hardware data acquisition/processing digital system with power output (motor drives) and bi-directional interface with computer (parallel port, EPP mode); authored the schematic and VHDL code for interface controller (PAL chip).  
Created software to interface with the hardware design: a 3-D graphical front-end utilizing C and Win32 API.

## Teaching Experience

6/2010–2/2012 Eberly Center for Teaching Excellence certification program

4/2010–2/2012 Founder

Center for Foundations of Robotics Lunch seminar series

- Led discussions on paper reviews and ideas for future research.
- Hosted visiting researchers as guest speakers.
- Obtained department funding for snacks at the meetings.

8/2007–12/2007 Teaching Assistant

Mobile Robot Programming Lab, Prof. Alonzo Kelly

- Wrote and graded homework assignments, designed exams.
- Tutored students during office hours.
- Taught two course lectures.
- Topics included sensing, localization and mapping, multi-robot coordination, path planning and control.

8/2002–6/2003 Tutor

Introduction to Logic Synthesis, Prof. Garrison Greenwood

- Tutored students during office hours.

- Topics included logic minimization, finite state machines, principles of digital design.

12/2001–6/2002 Tutor

Physics, Prof. John Abramson

- Tutored students during office hours.
- Topics included kinematics and dynamics, optics, acoustics, electricity and magnetism.

12/2000-6/2003 Lab instructor

PSU Robotics Lab

- Maintained lab resources and supervised student projects.
- Assisted students in programming, mechanical and electrical designs.

## Student Supervision and Advising

### Ph.D Committees

- Stephane Ross (Carnegie Mellon), *Efficient Reductions for Imitation Learning*: Qualifier passed March, 2011.

### M.S. Committees

- Vladimir Ermakov (Carnegie Mellon), *Data-driven Prediction of Environmental Events*: Defense expected December, 2011.
- Forrest Rogers-Marcovitz (Carnegie Mellon), *On-line Mobile Robotic Dynamic Modeling using Integrated Perturbative Dynamics*: Defended April, 2010.

### Graduate Research

- Vlad Ermakov and Prateek Tandon (Carnegie Mellon), *Nonlinear Optimization Techniques for Manipulator Kinematics Calibration*, January, 2011 – May, 2011.
- Philipp Krüsi (ETH Zurich, Switzerland), *Path Set Relaxation for Mobile Robot Navigation*: M.S. thesis supervision, November, 2009 – April, 2010.

### Undergraduate Research

- Collin Buchan (Junior, Carnegie Mellon), *Massively Parallel Covariant Optimization Planning on the GPU*, October, 2011 – present.
- Matt Klingensmith (Senior, Carnegie Mellon), *Covariant Optimization for Manipulation Planning*, October, 2010 – May, 2011.
- Jonathan Valz (Sophomore, Carnegie Mellon), *Obstacle Avoidance for Hybrid Mobility Systems*, May, 2010 – August, 2010.
- Ayman Singh (Senior, Carnegie Mellon), *Cost Functions for Base Placement Planning*, January, 2010 – June, 2010.

## Grants and Contracts

- 2012–2014 Army Research Laboratory Micro Autonomous Systems and Technology (MAST) program: *Fast, Online Generation of Motion Plans for Micro-UAVs with Incomplete Environment Models for Mapping* (\$250K), co-PIs: Mihail Pivtoraiko (proposal and execution lead) and Vijay Kumar.
- 2007–2010 Jet Propulsion Laboratory Strategic University Research Partnership (SURP) program: *Rough Terrain Rover Navigation via Planning with Motion Primitives* (\$100K overall), co-PIs: Mihail Pivtoraiko (proposal and execution lead) and Alonzo Kelly.

## **Service to the University**

### **Robotics Institute, CMU**

- 2010–2011 Center for Foundations of Robotics – Co-Czar, Webmaster
- 2008–2012 Ph.D. Program Committee – Student member
- 2008–2009 Summer Scholars Program – Admissions Committee member
- 2006–2008 RoboOrg – Officer

### **College of Engineering and Computer Science, PSU**

- 2000-2003 IEEE Robotics and Automation Society Chapter – President
- 2000-2003 IEEE Student Branch – Officer
- 2000-2002 Tau Beta Pi Engineering Honor Society Chapter – Officer

## **Service to the Research Community**

- Journal Review International Journal of Robotics Research; IEEE Transactions on Robotics and Automation; IEEE Transactions on Automatic Control; Intelligent Service Robotics; Journal of Field Robotics; Autonomous Robots; Robotics and Autonomous Systems.
- Conference Review International Conference on Robotics and Systems (RSS): 2007; International Conference on Robotics and Automation (ICRA): 2008, 2011; International Conference on Intelligent Robots and Systems (IROS): 2008, 2010, 2011; International Conference on Field and Service Robotics (FSR): 2007, 2009; International Conference on Autonomous Systems (IAS): 2008.
- Webmaster 7th International Conference on Field and Service Robotics, September, 2008 – June, 2009.

## **Service to the Public**

- 2001–2003 Habitat for Humanity – Volunteer
- 1997–2001 Portland Public Schools – Volunteer Interpreter and Teaching Assistant

## **Awards and Fellowships**

- 2009 Homayoun Seraji Best Paper Award, International Symposium on Learning and Adaptive Behavior in Robotic Systems
- 2009 NSF GRASSROOTS Travel Award
- 2008 Fulbright Fellowship, Finalist
- 2007–2010 NASA Graduate Student Research Program Fellow
- 2006–2012 Carnegie Mellon Robotics Graduate Fellow
- 2005 NSF Graduate Research Fellowship, Honorable Mention
- 2005 Hertz Foundation Graduate Fellowship, Finalist
- 2003 Undergraduate Research and Creative Activity Award
- 2002 PSU Donor Award
- 2002 Diversity Achievement Scholarship
- 2001, 2002 E.T.D. Jones Scholarship

2001	Intel Scholarship
2000, 2002	H. Chik M. Erzurumlu Scholarship
2000, 2001	NSF Award for Computer Science and Engineering
2000	PSU Honors College Washington, D.C. Internship Award
1999	David Douglas High School Memorial Scholarship and Service Award
1999	Junior Achievement Scholarship
1999	Ida M. Crawford Scholarship
2000, 2001, 2002	AeA Technology Scholarship

## Memberships

- 2010–present Association for the Advancement of Artificial Intelligence (AAAI)  
2003–present Association for Computing Machinery (ACM)  
2002–present Institute of Electrical and Electronics Engineers (IEEE)  
2001–present Tau Beta Pi Engineering Honor Society

## Publications

### Journal Papers

- Mihail Pivtoraiko**, Ross A. Knepper, and Alonzo Kelly. Differentially constrained mobile robot motion planning in state lattices. *Journal of Field Robotics*, 26(3):308–333, 2009.
- Martin Lukac, Marek Perkowski, Hilton Goi, **Mihail Pivtoraiko**, Chung Hyo Yu, Kyusik Chung, Hyunkoo Jee, Byung-Guk Kim, and Yong-Duk Kim. Evolutionary approach to quantum and reversible circuit synthesis. *Artificial Intelligence Review*, 20(3-4):361–417, 2003.

### Refereed Conference Papers

- Mihail Pivtoraiko** and Alonzo Kelly. Kinodynamic motion planning with state lattice motion primitives. In *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems*, 2011. Invited paper.
- Michael Fleder, Issa A.D. Nesnas, **Mihail Pivtoraiko**, Alonzo Kelly, and Richard Volpe. Autonomous rover traverse and precise arm placement on remotely designated targets. In *Proceedings of the International Conference on Robotics and Automation*, 2011.
- Mihail Pivtoraiko** and Alonzo Kelly. Graduated fidelity motion planning. In *Proceedings of the International Symposium on Combinatorial Search*, 2011.
- Philipp Krüsi, **Mihail Pivtoraiko**, Alonzo Kelly, Thomas M. Howard, and Roland Siegwart. Path set relaxation for mobile robot navigation. In *Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space*, 2010.
- Mihail Pivtoraiko**. Adaptive anytime motion planning for robust robot navigation in natural environments. In *AT-EQUAL '09: Proceedings of the 2009 Advanced Technologies for Enhanced Quality of Life*, pages 123–129, 2009. *Homayoun Seraji* best paper award.
- Mihail Pivtoraiko**, Issa A.D. Nesnas, and Alonzo Kelly. Autonomous robot navigation using advanced motion primitives. In *Proc. of the IEEE Aerospace Conference*, pages 1–7, March 2009.
- Jun young Kwak, **Mihail Pivtoraiko**, and Reid Simmons. Combining cost and reliability for rough terrain navigation. In *9th International Symposium on Artificial Intelligence, Robotics and Automation in Space*, 2008.
- Mihail Pivtoraiko**, Thomas Howard, Issa A.D. Nesnas, and Alonzo Kelly. Field experiments in rover navigation via model-based trajectory generation and nonholonomic motion planning in state lattices. In *Proceedings of the 9th International Symposium on Artificial Intelligence, Robotics, and Automation in Space*, 2008.
- Mihail Pivtoraiko** and Alonzo Kelly. Differentially constrained motion replanning using state lattices with graduated fidelity. In *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems*, pages 2611–2616, September 2008.
- Guillaume Brat, Ewen Denney, Kimberley Farrell, Dimitra Giannakopoulou, Ari Jonsson, Jeremy Frank, Mark Boddy, Todd Carpenter, Tara Estlin, and **Mihail Pivtoraiko**. A robust compositional architecture for autonomous systems. In *Proceedings of the IEEE Aerospace Conference*, page 8pp., 2006.

**Mihail Pivtoraiko** and Alonzo Kelly. Constrained motion planning in discrete state spaces. In *Field and Service Robotics*, pages 269–280, 2005.

**Mihail Pivtoraiko** and Alonzo Kelly. Generating near-minimal spanning control sets for constrained motion planning in discrete state spaces. In *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems*, pages 3231–3237, August 2005.

**Mihail Pivtoraiko** and Alonzo Kelly. Efficient constrained path planning via search in state lattices. In *Proceedings of the 8th International Symposium on Artificial Intelligence, Robotics and Automation in Space*, 2005.

Michele Folgheraiter, Giuseppina Gini, Marek Perkowski, and **Mihail Pivtoraiko**. Blackfingers: a sophisticated hand prosthesis. In *Proceedings of the International Conference on Rehabilitation Robotics*, 2003.

Martin Lukac, **Mihail Pivtoraiko**, Alan Mischenko, and Marek Perkowski. Automated synthesis of generalized reversible cascades using genetic algorithms. In *Proceedings of the International Symposium on Boolean Problems*, Freiberg, Germany, 2002.

### Workshops

**Mihail Pivtoraiko** and Alonzo Kelly. Rover trajectory planning: Constrained global planning and path relaxation. In *International Conference on Robotics and Automation*. 2010.

**Mihail Pivtoraiko** and Alonzo Kelly. Fast and feasible deliberative motion planner for dynamic environments. In *International Conference on Robotics and Automation*. 2009.

### Technical Reports

**Mihail Pivtoraiko**, Ross A. Knepper, and Alonzo Kelly. Optimal, smooth, nonholonomic mobile robot motion planning in state lattices. Technical Report CMU-RI-TR-07-15, Robotics Institute, Carnegie Mellon University, 2007.

**Mihail Pivtoraiko**. A study of polynomial curvature clothoid paths for motion planning for car-like robots. Technical Report CMU-RI-TR-04-68, Robotics Institute, Carnegie Mellon University, 2004.

## Presentations

### Invited Talks at Conferences

9/2011 International Conference on Intelligent Robots and Systems (IROS).

### Invited Talks at Research Institutions

*Automatic Search Space Design for Differentially Constrained Replanning:*

8/2010 Department of Computer Science, University of Illinois, Urbana, IL.

8/2010 GRASP Lab, University of Pennsylvania, Philadelphia, PA.

8/2010 Department of Electrical Engineering and Computer Science, University of California, Berkeley.

8/2010 Artificial Intelligence Laboratory, Stanford University, Palo Alto, CA.

*Differentially Constrained Incremental Replanning:*

5/2009 Digital Human Lab, AIST, Tokyo, Japan.

5/2009 Tohoku University, Sendai, Japan.

*Planning with Graduated Fidelity:*

8/2008 Jet Propulsion Lab, Pasadena, CA.



*Rover Navigation: Trajectory Generation and Motion Planning:*

7/2005 NASA Ames Research Center, Moffett Field, CA.

*Efficient Constrained Path Planning Via Search in State Lattices:*

9/2004 Jet Propulsion Lab, Pasadena, CA.

### **Technical Demos**

M. Kazemi, **M. Pivtoraiko**, L. Cui, T. Galluzzo, J.-S. Valois, D. Bagnell, *Autonomous Robotic Manipulation:*

7/2011 Voice of America lab visit, National Robotics Engineering Center (NREC), Pittsburgh, PA.

**M. Pivtoraiko** and I. Nefas, *Graduated Fidelity Replanning on the FIDO Research Prototype Rover:*

6/2008 Mars Technology Program Annual Review, Mars Yard, Jet Propulsion Laboratory, Pasadena, CA.

5/2008 ICRA Demo Day, Mars Yard, Jet Propulsion Laboratory, Pasadena, CA.

5/2008 JPL Open House, Building 198 demo area, Jet Propulsion Laboratory, Pasadena, CA.

J. Kwak, **M. Pivtoraiko** and I. Nefas, *Combining Cost and Reliability for Rough Terrain Navigation:*

6/2008 Mars Technology Program Annual Review, Mars Yard, Jet Propulsion Laboratory, Pasadena, CA.

### **Miscellaneous**

*Citizenship:* United States of America, NACI HSPD-12 clearance.

*Languages:* English, Ukrainian, Russian (fluent); French (conversational); Japanese (beginner).

*Hobbies:* Photography, piano, guitar, accordion.

January 29, 2015